US009195173B2

(12) **United States Patent**
Ogawa et al.

(10) **Patent No.: US 9,195,173 B2**
(45) **Date of Patent: Nov. 24, 2015**

(54) **DEVELOPING DEVICE AND IMAGE FORMING APPARATUS AND PROCESS CARTRIDGE INCORPORATING SAME**

(71) Applicants: **Tadashi Ogawa**, Tokyo (JP); **Atsushi Nakamoto**, Kanagawa (JP)

(72) Inventors: **Tadashi Ogawa**, Tokyo (JP); **Atsushi Nakamoto**, Kanagawa (JP)

(73) Assignee: **Ricoh Company, Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/293,018**

(22) Filed: **Jun. 2, 2014**

(65) **Prior Publication Data**

US 2014/0376951 A1 Dec. 25, 2014

(30) **Foreign Application Priority Data**

Jun. 20, 2013 (JP) 2013-129376

(51) **Int. Cl.**
G03G 21/00 (2006.01)
G03G 15/08 (2006.01)
G03G 21/18 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0898*** (2013.01); *G03G 21/18* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0875; G03G 15/0877; G03G 15/0898
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0165443	A1	7/2006	Yoshinaga et al.	
2006/0177232	A1	8/2006	Ehara et al.	
2007/0003325	A1 *	1/2007	Jung et al.	399/258
2007/0059011	A1	3/2007	Seo et al.	
2007/0242988	A1	10/2007	Seo et al.	
2011/0091253	A1	4/2011	Seo et al.	
2011/0129262	A1	6/2011	Nakamoto	
2011/0217085	A1	9/2011	Hattori et al.	
2012/0093531	A1	4/2012	Yuasa et al.	
2012/0107005	A1	5/2012	Hase et al.	
2012/0118834	A1 *	5/2012	Gier-Zucketto et al.	210/767
2012/0163874	A1	6/2012	Hattori et al.	
2012/0219326	A1	8/2012	Koike et al.	
2013/0034368	A1	2/2013	Hattori et al.	
2013/0209115	A1	8/2013	Hase et al.	
2014/0270838	A1 *	9/2014	Yoshizawa et al.	399/99

FOREIGN PATENT DOCUMENTS

JP	61-159676	7/1986
JP	2007-248629	9/2007
JP	2012-189787	10/2012

* cited by examiner

Primary Examiner — Roy Y Yi
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A developing device includes a developer bearer to carry by rotation developer to a development range facing a latent image bearer, a developer container to contain developer and having a pressure-release vent to discharge air from the developer container to outside the developing device, and a filter provided to the pressure-release vent to inhibit developer from being discharged through the pressure-release vent. The filter includes a porous fluoroplastic film.

8 Claims, 6 Drawing Sheets

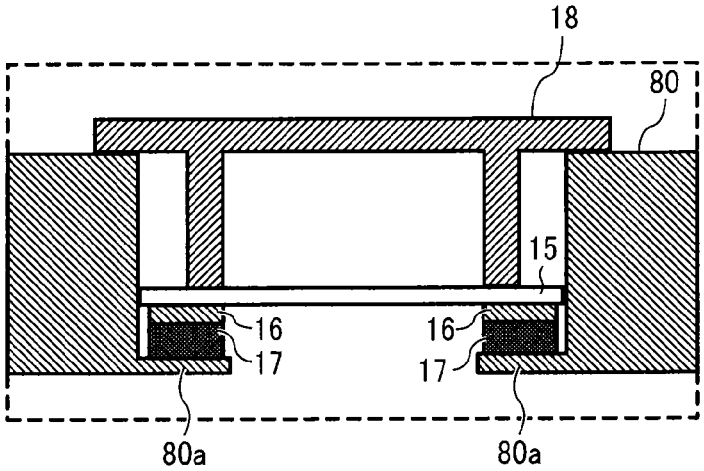
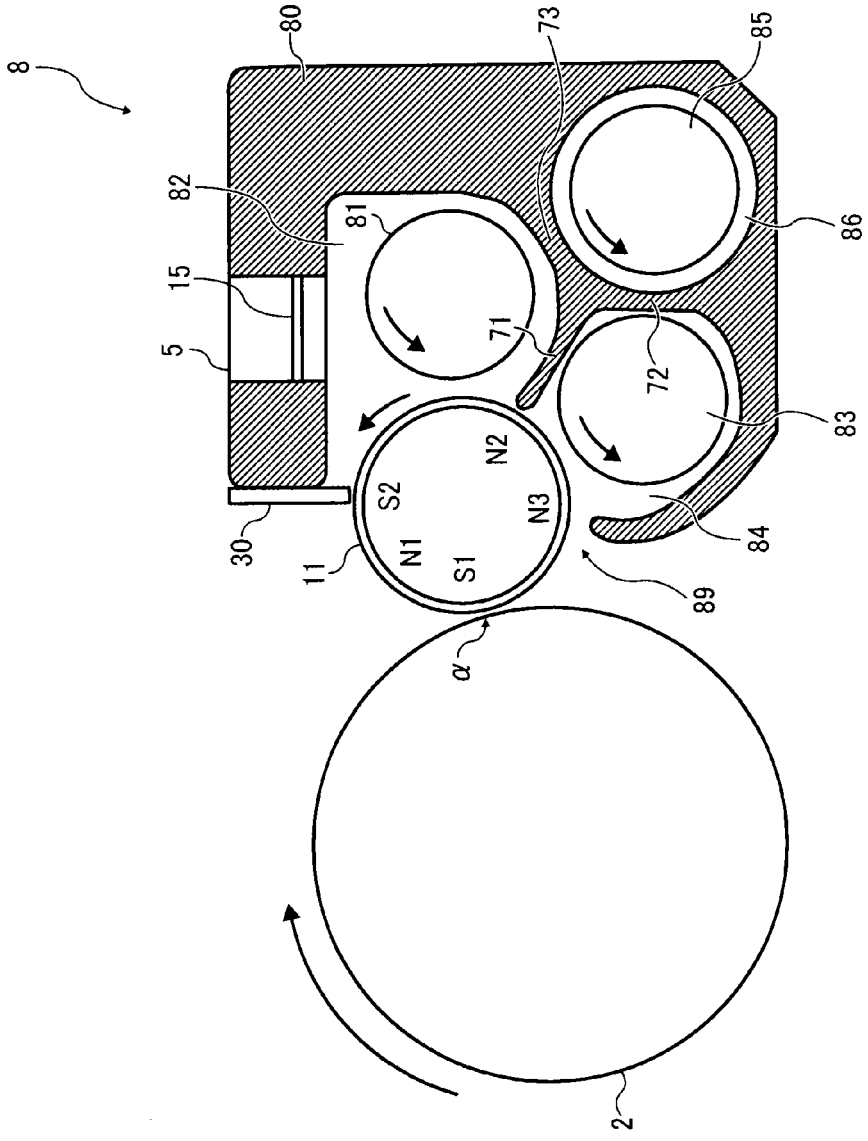


FIG. 1



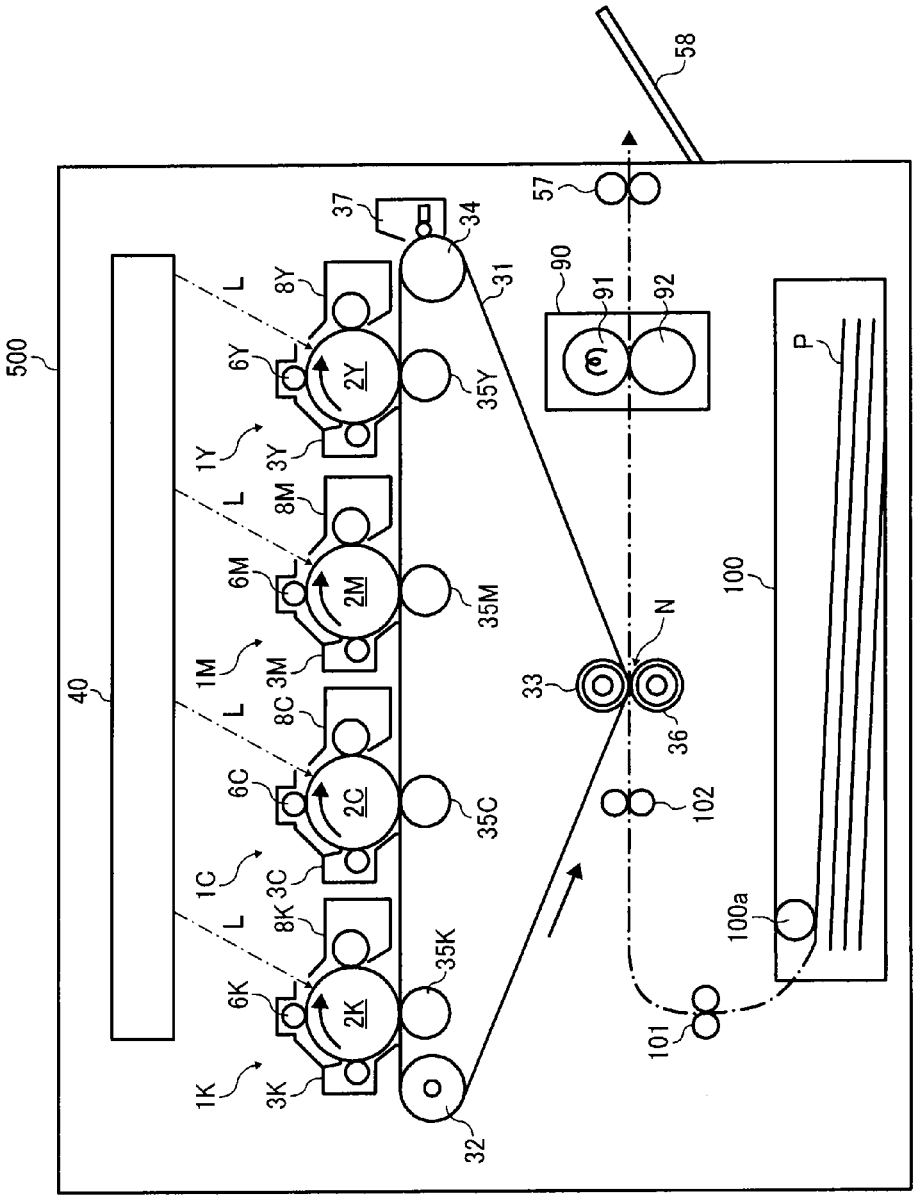

500
40
L
1Y
1M
1C
1K
8Y
8M
8C
8K
6Y
6M
6C
6K
2Y
2M
2C
2K
3Y
3M
3C
3K
37
34
31
35Y
35M
35C
35K
32
57
58
90
91
92
33
N
36
102
101
100
100a
P

FIG. 2

FIG. 3

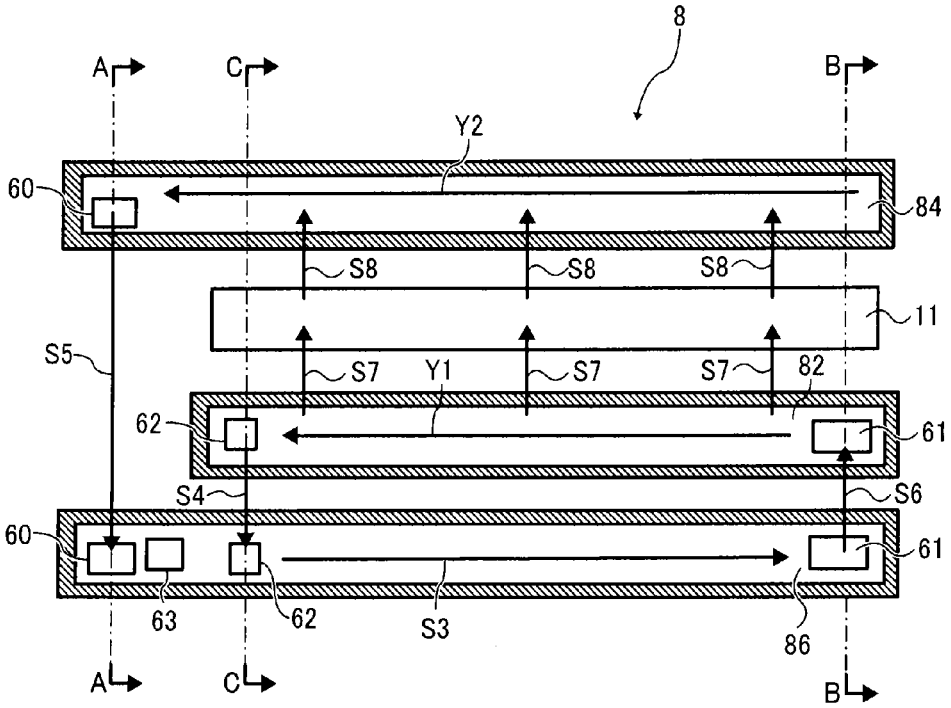

8
A
C
B
Y2
60
84
S8
S8
S8
11
S5
S7
Y1
S7
S7
82
62
61
S4
S6
60
61
63
62
S3
86
A
C
B

FIG. 4

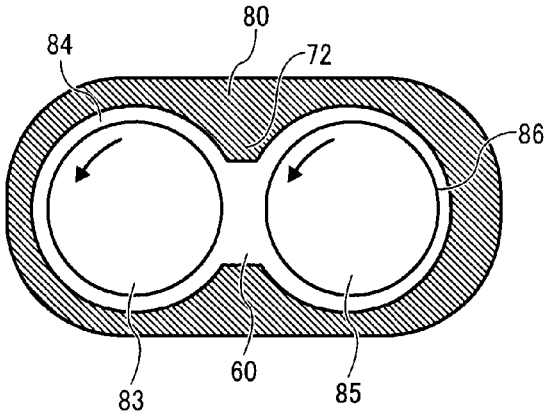

80
84
72
86
83
60
85

FIG. 6

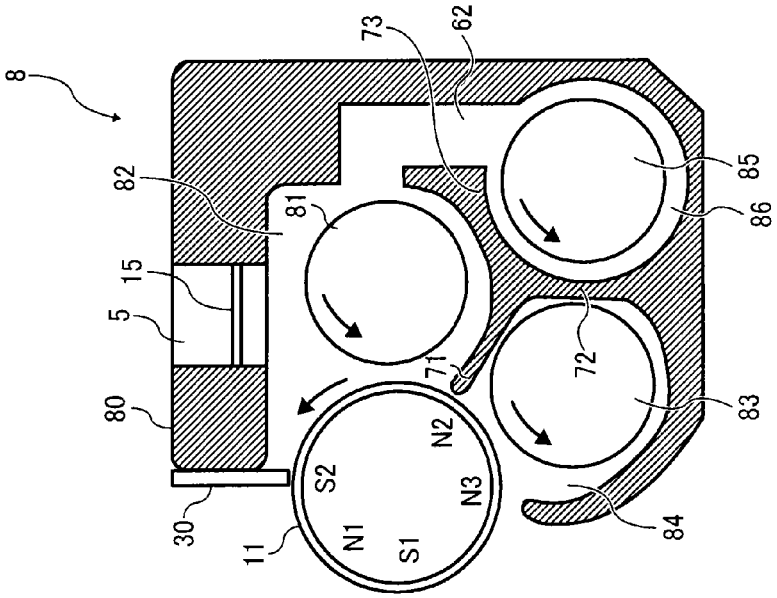

8
73
62
82
81
85
86
15
5
71
72
80
83
N2
S2
N3
30
N1
S1
11
84

FIG. 5

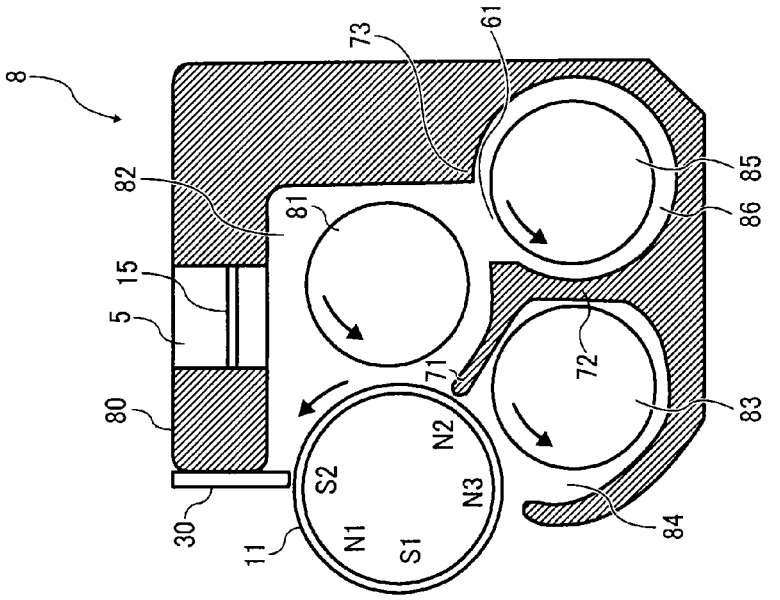

8
73
61
82
81
85
86
15
5
71
72
80
83
N2
S2
N3
30
N1
S1
11
84

FIG. 7A

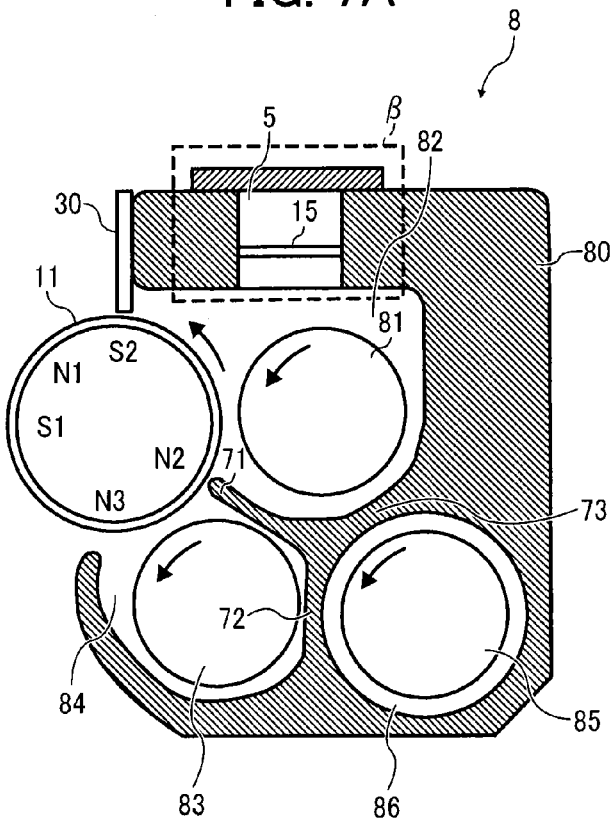

8
5
β
82
30
15
80
11
81
S2
N1
S1
N2
71
N3
73
72
84
85
83
86

FIG. 7B

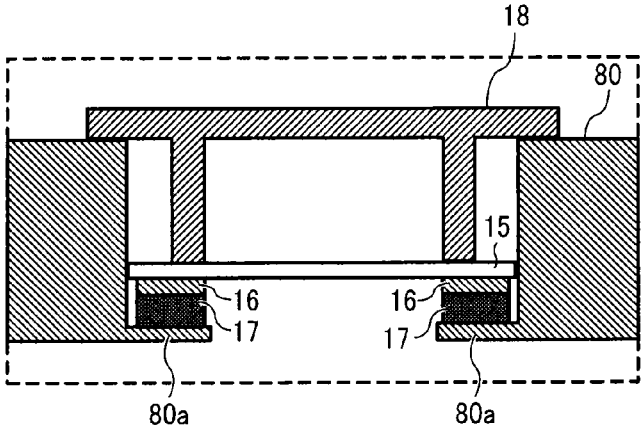

18
80
15
16
16
17
17
80a
80a

FIG. 7C

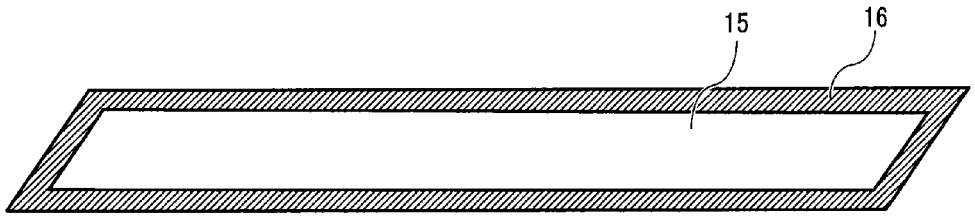
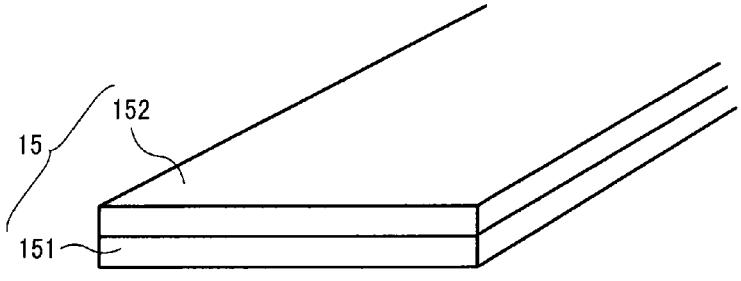


FIG. 8



DEVELOPING DEVICE AND IMAGE FORMING APPARATUS AND PROCESS CARTRIDGE INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is based on and claims priority pursuant to 35 U.S.C. §119(a) to Japanese Patent Application No. 2013-129376, filed on Jun. 20, 2013, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

1. Technical Field

Embodiments of the present invention generally relate to a developing device, a process cartridge, and an image forming apparatus, such as a copier, a printer, a facsimile machine, or a multifunction machine having at least two of coping, printing, facsimile transmission, plotting, and scanning capabilities, that includes a developing device.

2. Description of the Related Art

Image forming apparatuses typically include a developing device to develop latent images formed on a latent image bearer (e.g., a photoreceptor) with developer, and two-component developer consisting essentially of toner (toner particles) and magnetic carrier (carrier particles) is widely used. Developing devices of this type typically include a rotatable developer bearer inside which multiple magnetic poles are provided. For example, JP-H06-019637-A, JP-2012-189787-A, and JP-2007-248629-A propose such configurations.

In such developing devices, the developer bearer carries developer on its surface and transports the developer to a development range facing the latent image bearer, where toner in the developer is supplied to the latent image on the surface of the latent image bearer.

The developer bearer is disposed in a casing serving as a developer container to contain developer, and the surface of the developer bearer is partly exposed in the development range through an opening of the casing. Inside the casing (i.e., the developer container), while developer is circulated by one or multiple developer conveyance members, a part of circulating developer is supplied to the surface of the developer bearer. The amount of developer supplied to the developer bearer is adjusted at a position where the developer bearer faces a developer regulator, after which the developer is transported to the development range. After the toner therein is consumed in the development range, the developer leaves the surface of the developer bearer. Then, the developer is collected in the developer container and circulated together with the developer therein.

To enable high-speed output in this developing device, the velocity at which the surface of the developer bearer moves (hereinafter "surface movement velocity") is increased. However, if the surface movement velocity is increased, it is possible that air pressure inside the developer container rises as follows.

The surface of the developer bearer moving at a high velocity causes airflow that follows the movement of the developer bearer. When the exposed surface of the developer bearer returns from the opening in the development range to inside the casing, air flows into the casing as well.

By contrast, on the surface of the developer bearer moving toward the development range, developer fills a gap (i.e., a regulation gap) between the developer regulator and the surface of the developer bearer, which inhibits air from flowing out from the opening together with the surface of the developer bearer.

In a state in which the casing is substantially filled with developer other than the opening, air pressure inside the developer container rises when air flows into the casing but does not flow out therefrom.

If air pressure rises inside the developer container, there arises a risk that toner scatters out together with air from a small clearance between the developer container and the developer bearer moving to the development range, seams of the developer container, or the like. Scattering of toner is not desirable since it causes stains on output images, contamination inside an image forming apparatus, and the like.

The patent documents listed above propose use of a pressure-release vent to discharge air from the developer container and a filter to inhibit passage of toner, thereby inhibiting toner scattering from the opening. In this configuration, pressure rise inside the developer container can be inhibited since air is released from the developer container. Accordingly, toner scattering resulting from the pressure rise inside the developer container can be suppressed.

SUMMARY

In view of the foregoing, one embodiment of the present invention provides a developing device that includes a developer bearer to carry by rotation developer to a development range facing a latent image bearer and supply developer to a latent image on the latent image bearer, a developer container to contain developer and having a pressure-release vent to discharge air from the developer container to outside the developing device, and a filter provided to the pressure-release vent to inhibit developer from being discharged through the pressure-release vent. The filter includes a porous fluoroplastic film.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a cross-sectional view of a developing device according to an embodiment;

FIG. **2** is a schematic diagram of an image forming apparatus in which the developing device shown in FIG. **1** is incorporated;

FIG. **3** illustrates circulation of developer in the developing device shown in FIG. **1**;

FIG. **4** is a cross sectional view along line A-A shown in FIG. **3**;

FIG. **5** is a cross sectional view along line B-B shown in FIG. **3**;

FIG. **6** is a cross sectional view along line C-C shown in FIG. **3**;

FIG. **7**A is a cross-sectional view of a developing device provided with a pressure-release filter according to an embodiment;

FIG. **7**B is an enlarged view of a range β shown in FIG. **7**A;

FIG. **7**C is a perspective view of the pressure-release filter shown in FIG. **7**A, and

FIG. **8** is an enlarged perspective view illustrating double-layered filter as a variation of the pressure-release filter shown in FIGS. **7**A through **7**C.

DETAILED DESCRIPTION

In describing preferred embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

In developing devices including a filter provided to a pressure-release vent, it is possible that toner filtered thereby remains on the face (i.e., inner face) of the filter opposed to the interior of the developing device, and the toner accumulates on the filter, clogging the filter.

This inconvenience arises in developing devices employing one-component developer as well as in developing devices employing two-component developer.

In view of the foregoing, an aim of the embodiments described below is to provide a developing device capable of inhibiting clogging of the filter at the pressure-release vent, and a process cartridge and an image forming apparatus that include the developing device.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views thereof, an embodiment of the present invention is described.

FIG. **1** illustrates a photoreceptor **2** and a developing device **8** to which aspects of the present specification are applicable, and FIG. **2** is a schematic view of an image forming apparatus **500** that in the present embodiment is a multicolor printer, for example.

It is to be noted that suffixes Y, M, C, and K attached to each reference numeral indicate only that components indicated thereby are used for forming yellow, magenta, cyan, and black images, respectively, and hereinafter may be omitted when color discrimination is not necessary.

A configuration and operation of the image forming apparatus **500** is described below.

In the configuration shown in FIG. **2**, the image forming apparatus **500** is a tandem-type printer and include multiple independent optical systems and latent image bearers for forming yellow, magenta, cyan, and black images. The image forming apparatus **500** transfers multiple color toner images from the respective latent image bearer and superimposes them on an intermediate transfer member. The superimposed toner image on the intermediate transfer member is then transferred onto a sheet serving as a recording medium, thereby forming a multicolor image.

The image forming apparatus **500** includes four image forming units **1**Y, **1**M, **1**C, and **1**K for forming yellow, magenta, cyan, and black toner images, respectively. Each image forming unit **1** includes a drum-shaped photoreceptor **2** serving as an image bearer or latent image bearer. The four photoreceptors **2** rotate clockwise in FIG. **2** as indicated by arrow shown in FIG. **2**. Around the photoreceptor **2**, a charging device **6** serving as a charging member, a developing device **8**, and a cleaning device **3** are provided.

Additionally, an exposure device **40** is provided above the image forming units **1** in FIG. **2** to direct exposure light L onto the surface of the photoreceptor **2** positioned between the charging device **6** and the developing device **8** in each image forming unit **1**.

The image forming unit **1** includes a common unit casing to support the photoreceptor **2**, the developing device **8**, and the cleaning device **3** together and is configured as a modular unit (i.e., a process cartridge) removably installable in an apparatus body of the image forming apparatus **500**. It is to be noted that, alternatively, the developing device **8** and at least one of the photoreceptor **2**, the charging device **6**, and the cleaning device **3** may be united together as the process cartridge. Yet alternatively, at least two of the photoreceptor **2**, the charging device **6**, the developing device **8**, and the cleaning device **3** may be united together as the process cartridge.

In the image forming apparatus **500**, an endless intermediate transfer belt **31** serving as the intermediate transfer member is provided beneath the four image forming units **1** in FIG. **2**. As shown in FIG. **2**, the intermediate transfer belt **31** is looped around three rollers, namely, a driving roller **32**, a secondary-transfer backup roller **33**, and a cleaning backup roller **34**, and rotatable counterclockwise in FIG. **2**. At positions opposed to the four photoreceptors **2** via the intermediate transfer belt **31**, primary-transfer rollers **35**, serving as primary transfer members, are provided.

Beneath the intermediate transfer belt **31**, a secondary-transfer roller **36**, serving as a secondary transfer member, is provided. Among the three rollers supporting the intermediate transfer belt **31**, the secondary-transfer backup roller **33** is in contact with the secondary-transfer roller **36** via the intermediate transfer belt **31**. The contact portion between the intermediate transfer belt **31** and the secondary-transfer roller **36** serves as a secondary-transfer nip N where the toner image is transferred from the intermediate transfer belt **31** onto a sheet P.

Another one of the rollers supporting the intermediate transfer belt **31**, the cleaning backup roller **34**, is opposed, via the intermediate transfer belt **31**, to an intermediate-transfer cleaner **37** to remove toner remaining on the intermediate transfer belt **31** after image transfer.

Beneath the secondary-transfer roller **36** in FIG. **2**, a sheet tray **100** containing sheets P is provided. Broken lines shown in FIG. **2** represent a conveyance channel through which the sheet P is transported inside the image forming apparatus **500**.

A fixing device **90** is disposed downstream from (on the right in FIG. **2**) the secondary-transfer nip N in the direction in which the sheet P is transported (i.e., a sheet conveyance direction). The fixing device **90** includes a heating roller **91** inside which a heater is provided and a pressure roller **92** pressed against the heating roller **91** by a spring, forming a nip therebetween.

Next, multicolor image formation in the image forming apparatus **500** is described below.

To form images, the driving roller **32** is driven to rotate the intermediate transfer belt **31**, and the other two rollers (**33** and **34**) rotate. Simultaneously, the photoreceptors **2** in the four image forming units **1** are rotated.

Then, the charging device **6** charges the photoreceptor **2** uniformly, and the exposure device **40** exposes the photoreceptor **2**, thereby forming an electrostatic latent image thereon. The developing device **8** develops the electrostatic latent image with toner, thereby forming a toner image. The primary-transfer rollers **35** transfers the toner images from the respective photoreceptors **2** and superimpose them one on another on the intermediate transfer belt **31**, thereby forming a multicolor toner image on the intermediate transfer belt **31**. The multicolor toner image is transported to the secondary-transfer nip N as the intermediate transfer belt **31** looped around the multiple rollers rotates.

Meanwhile, in the sheet tray **100**, a feed roller **100***a* forwards the sheet P therefrom by rotating. The sheet P is separated one by one by a separating roller and fed to the sheet conveyance channel. The sheet P is transported by conveyance rollers **101** and caught in a nip between registration rollers **102**.

The registration rollers **102** rotate to transport the sheet P to the secondary-transfer nip N, time to coincide with the arrival of the multicolor toner image formed on the intermediate transfer belt **31**. In the secondary-transfer nip N, the toner image is transferred from the intermediate transfer belt **31** onto the sheet P by a transfer electrical field generated between the secondary-transfer roller **36** and the secondary-transfer backup roller **33**. Subsequently, the intermediate-transfer cleaner **37** removes toner remaining on the intermediate transfer belt **31**, and the four image forming units **1** are prepared for subsequent image formation.

The sheet P is transported to the fixing device **90**. In the fixing device **90**, the toner image is fixed on the sheet P with heat and pressure in the nip where the pressure roller **92** presses against the heating roller **91**.

Then, the sheet P is discharged by a pair of discharge rollers **57** and stacked on a discharge tray **58**.

The developing device **8** is described in further detail below with reference to FIGS. **1** and **3** through **6**.

The four developing devices **8**Y, **8**M, **8**C, and **8**K have a similar configuration except the color of toner used therein, and thus suffixes Y, M, C, K representing the respective colors are omitted in the description below and accompanying drawings.

FIG. **3** is a schematic diagram illustrating circulation of developer in the developing device **8**. FIGS. **4**, **5**, and **6** are cross sectional views of the developing device **8** along line A-A, line B-B, and line C-C shown in FIG. **3**, respectively.

The developing device **8** includes a developing roller **11** as a developer bearer and multiple developer conveying screws (i.e., developer conveyance members), namely, a supply screw **81**, a collecting screw **83**, and a circulation screw **85**.

The developing roller **11** is cylindrical, and includes a sleeve that rotates counterclockwise in FIG. **1** and a magnet roller provided inside the sleeve. The sleeve can be constructed of a nonmagnetic material. The magnet roller is stationary relative to a development casing **80** serving as a developer container to contain developer. The magnet roller serves as a magnetic field generator and has five magnetic poles, N**1**, S**1**, N**2**, N**3**, and S**2** at predetermined positions.

The development casing **80** is divided into a supply channel **82**, a collecting channel **84**, and a circulation channel **86** (collectively "developer containing channels"). The developing device **8** further includes a regulation blade **30**. The regulation blade **30** is attached to the development casing **80** to face an upper portion of the developing roller **11** contactlessly with the developing roller **11**. The regulation blade **30** is oriented to the surface of the sleeve adjacent to the magnetic pole S**2** at a highest position of the magnet roller. The regulation blade **30** regulates the height of a magnetic brush of developer carried on the developing roller **11** and transported to a development range α, thereby regulating the amount of developer on the developing roller **11**. In the present embodiment, the development casing **80** contains two-component developer (hereinafter simply "developer") including yellow, magenta, cyan, or black toner particles (also simply "toner") and magnetic carrier particle (also simply "carrier"). The development casing **80** is provided with an opening **89** (shown in FIG. **1**) opposed to the photoreceptor **2**, and the outer circumferential face of the developing roller **11** is partly exposed through the opening **89**.

The sleeve of the developing roller **11** (hereinafter "developing sleeve") is disposed across a predetermined gap from the photoreceptor **2**. In FIG. **1**, the developing sleeve rotates counterclockwise, and the photoreceptor **2** rotates clockwise as indicated by arrows shown in FIG. **1**. Thus, in the development range α, the developing sleeve and the photoreceptor **2** move in an identical direction.

The supply screw **81**, the collecting screw **83**, and the circulation screw **85** are respectively disposed in the supply channel **82**, the collecting channel **84**, and the circulation channel **86** inside the development casing **80**.

In FIG. **3**, arrow Y**1** represents the direction in which developer is transported in the supply channel **82** by the supply screw **81** (hereinafter "conveyance direction of the supply screw **81**"), and arrow Y**2** represents the direction in which developer is transported in the collecting channel **84** by the collecting screw **83** (hereinafter "conveyance direction of the collecting screw **83**"). Additionally, arrow S**3** in FIG. **3** represents the direction in which developer is transported in the circulation channel **86** by the circulation screw **85** (hereinafter "conveyance direction of the circulation screw **85**").

As shown in FIG. **1**, a partition **71** is disposed between the supply channel **82** provided with the supply screw **81** and the collecting channel **84** provided with the collecting screw **83** to inhibit movement of developer therebetween. Additionally, a partition **72** is disposed between the collecting channel **84** and the circulation channel **86** provided with the circulation screw **85** to inhibit movement of developer therebetween. Further, a partition **73** is disposed between the circulation channel **86** and the supply channel **82** to inhibit movement of developer therebetween. In the developing device **8** shown in FIGS. **1**, **3**, and **6**, the partitions **71**, **72**, and **73** are monolithic with the development casing **80**. The developing roller **11** transports the developer supplied from the supply channel **82** to the development range α facing the photoreceptor **2**.

The partitions **72** and **73** include communication openings to circulate developer among the supply channel **82**, the collecting channel **84**, and the circulation channel **86**.

For example, as shown in FIGS. **3** and **4**, the partition **72** separating the collecting channel **84** from the circulation channel **86** includes a communication opening **60** in a downstream end portion in the conveyance direction of the collecting screw **83**, and developer is discharged through the communication opening **60** from the collecting channel **84** to the circulation channel **86**.

As shown in FIGS. **3** and **5**, the partition **73** separating the circulation channel **86** from the supply channel **82** includes a communication opening **61** in a downstream end portion in the conveyance direction of the circulation screw **85**, and developer is discharged from the circulation channel **86** to the supply channel **82** through the communication opening **61**. Further, as shown in FIGS. **3** and **6**, the partition **73** includes a communication opening **62** in a downstream portion in the conveyance direction of the supply screw **81**. At the downstream end of the supply channel **82** in the conveyance direction of the supply screw **81**, developer is discharged through the communication opening **62** to the circulation channel **86** as indicated by arrow S**4** shown in FIG. **3**.

Arrow S**5** shown in FIG. **3** indicates the direction of flow of developer discharged from the downstream end of the collecting channel **84** in the conveyance direction of the collecting screw **83** and received through the communication opening **60** in the circulation channel **86**. Further, arrow S**6** shown in FIG. **3** indicates the direction of flow of developer discharged from the downstream end of the circulation channel **86** in the conveyance direction of the circulation screw **85** and received through the communication opening **61** in the supply channel **82**.

Additionally, a toner supply inlet **63**, through which toner is supplied to the developing device **8**, is provided adjacent to the upstream end of the circulation channel **86** in the conveyance direction of the circulation screw **85**. Specifically, the

toner supply inlet **63** is downstream from the communication opening **60** and upstream from the communication opening **62** in the conveyance direction of the circulation screw **85** in the circulation channel **86**.

Both ends of each of the three developer conveying screws (**81**, **83**, and **85**) and the developing roller **11** are rotatably supported by the development casing **80**. These components are rotated in the directions indicated by arrows shown in FIG. **1** by a driving unit including a driving source and a drive transmission mechanism.

The supply screw **81** supplies developer to the developing roller **11** while transporting and agitating the developer along its rotation shaft. The collecting screw **83** collects developer from the developing roller **11** while transporting and agitating the developer along its rotation shaft. Further, the circulation screw **85** mixes the toner supplied through the toner supply inlet **63** and the existing developer while transporting the developer along its rotation shaft.

The rotation shafts of the three developer conveying screws (**81**, **83**, and **85**) are parallel to the axis of rotation of the photoreceptor **2**. In a vertical direction in FIG. **1**, the supply screw **81** is positioned higher than the collecting screw **83** and the circulation screw **85**. Driven by driving force from the drive source, these developer conveying screws rotate and transport developer inside the developing device **8**. Then, developer is circulated inside the development casing **80** as indicated by arrows Y**1**, Y**2**, and S**3** through S**6**.

While transporting developer in the supply channel **82**, the supply screw **81** supplies the developer to the developing roller **11** as indicated by arrows S**7**, and the developer is scooped up to the surface of the developing roller **11** by the magnetic pole N**2**. Then, the developer is retained on the surface of the developing roller **11** and becomes the magnetic brush due to the magnetic force exerted by the magnet roller inside the developing roller **11**. As the developing sleeve rotates, the developer retained on the surface of the developing roller **11** is transported from a position facing the magnetic pole S**2** to a position facing the magnetic pole N**1** and further to a position facing the magnetic pole S**1**. Then, the developer reaches the development range α where the developing roller **11** faces the photoreceptor **2**. During the transportation, while the developer retained by the magnetic force exerted by the magnetic pole S**2** passes through the portion facing the regulation blade **30**, the developer is regulated into a thin layer. The developer blocked by the regulation blade **30** is returned to the supply channel **82**.

The magnetic pole S**1** is a main development pole and causes developer to stand on end in the development range α. Then, the developer contacts the surface of the photoreceptor **2** and develops the electrostatic latent image on the photoreceptor **2**. After developing the latent image, the developer leaves the development range α and returns into the development casing **80** as the developing sleeve rotates. Then, the developer is separated from the surface of the developing roller **11** by a repulsive magnetic field between the magnetic poles N**2** and N**3** and collected in the collecting channel **84**.

Meanwhile, a part of the developer inside the supply channel **82** is not supplied to the developing roller **11** and transported to the development range α but is transported by the supply screw **81** to or adjacent to the downstream end of the supply channel **82** in the developer conveyance direction therein.

As shown in FIG. **6**, an entrance of the communication opening **62**, which is adjacent to the downstream end of the supply channel **82** in the conveyance direction of the supply screw **81**, is positioned higher than a lowest position in the supply channel **82**.

Out of the developer transported inside the supply channel **82** by the supply screw **81** to the position adjacent to the communication opening **62**, the developer at or higher than a lowest portion of the entrance of the communication opening **62** falls therethrough to the circulation channel **86**.

By contrast, out of the developer transported to the communication opening **62**, the developer that does not reach the lowest portion of the entrance of the communication opening **62** is supplied to the developing roller **11** while transported further downstream by the supply screw **81**. Accordingly, on the downstream side in the supply channel **82**, the bulk of developer decreases gradually and becomes lower than a lowest portion of the supply screw **81**.

Although the bulk of developer may increase at the extreme downstream of the supply channel **82** that is a dead end, the developer returns to the communication opening **62** against the conveyance force of the supply screw **81** when the developer acculturates to a certain level. Then, the developer at or higher than the lowest portion of the entrance of the communication opening **62** falls therethrough to the circulation channel **86**.

With this behavior, in the supply channel **82**, the bulk of developer does not keep increasing downstream from the communication opening **62**, and the developer reaches a state of equilibrium having a gradient adjacent to the extreme downstream of the communication opening **62**.

The developer carried through the development range α by the developing roller **11** and deprived of toner is collected from the developing roller **11** into the collecting channel **84** as indicated by arrow S**8** shown in FIG. **3**. The developer inside the collecting channel **84** is agitated and transported downstream in the conveyance direction of the collecting screw **83**. Then, the developer moves from the downstream end portion of the collecting channel **84** through the communication opening **60** to the circulation channel **86**. In the circulation channel **86**, while transported by the circulation screw **85**, the developer is mixed with the toner supplied from the toner supply inlet **63** and further with the developer falling through the communication opening **62** from the supply channel **82**. In the circulation channel **86**, the circulation screw **85** transports developer downstream (to the right in FIG. **3**).

In the circulation channel **86**, within the width of an image area in which latent images are formed on the photoreceptor **2**, developer is transported and agitated in a state closed by the partitions **72** and **73** to inhibit the developer from being mixed with the developer being transported by the other screws.

In the downstream end portion of the circulation channel **86** in the conveyance direction of the circulation screw **85**, the communication opening **61** opens upward, and the circulation screw **85** lifts the developer inside the circulation channel **86** through the communication opening **61** to the supply channel **82**.

Next, a distinctive feature of the present embodiment is described below.

As shown in FIG. **1** and the like, the developing device **8** further includes a pressure-release vent **5** above the supply channel **82** in the development casing **80**, and a pressure-release filter **15** is provided to the pressure-release vent **5**. In the present embodiment, the pressure-release filter **15** includes a porous fluoroplastic film such as a porous PFA (copolymer of tetrafluoroethylene and perfluoroalkyl vinyl ether) film.

When the developing device **8** is driven, the pressure (i.e., internal pressure) inside the development casing **80** (the supply channel **82**, the collecting channel **84**, and the circulation channel **86**) rises. With the internal pressure rise, air flows from the developer containing channels toward the outside

the development casing **80** through the pressure-release vent **5**, and thus air flows out the development casing **80**. Accordingly, the internal pressure rise can be inhibited, and toner scattering resulting therefrom can be inhibited. Additionally, the pressure-release filter **15** provided to the pressure-release vent **5** can inhibit toner and carrier from flowing out the development casing **80** together with air.

Although filters constructed of raising (or napped) materials, sponge, or the like are conventionally provided to pressure-release vents, toner and carrier filtered by the filter are likely to remain on the inner face of the filter facing the developer containing channels, thus clogging the filter. Clogging of the pressure-release filter **15** increases pressure loss when air passes through the pressure-release filter **15**. If the pressure loss increases, it degrades the efficiency in discharging air when the internal pressure of the developer containing channels rises, and the pressure rise is not suppressed sufficiently. Thus, toner scattering arises.

By contrast, in the developing device **8** according to the present embodiment, the pressure-release filter **15** is constructed of the porous fluoroplastic film. The surface of porous fluoroplastic film is smooth and has a high capability to release toner and carrier. Accordingly, even when toner filtered adheres to the inner face of the pressure-release filter **15** opposed to the developer containing channels, the toner is not likely to remain thereon. Accordingly, accumulation of toner and carrier on the pressure-release filter **15** and clogging of the pressure-release filter **15** caused thereby can be inhibited. Therefore, the developing device **8** according to the present embodiment can inhibit clogging of the pressure-release filter **15** and suppress toner scattering caused by the internal pressure rise resulting from the clogged pressure-release filter **15**.

It is to be noted that, the porous fluoroplastic for the pressure-release filter **15** is not limited to porous PFA but can include other types of porous fluoroplastic such as porous PTFE (polytetrafluoroethylene).

The pressure-release filter **15** is described in further detail below. FIG. **7**A is a cross-sectional view of the developing device **8** provided with the pressure-release filter **15**, FIG. **7**B is an enlarged view of a range β shown in FIG. **7**A, and FIG. **7**C is a perspective view of the pressure-release filter **15**.

In the present embodiment, the porous PFA used for the pressure-release filter **15** has a pore diameter of 10 μm or smaller. When the average particle size of toner is smaller than 10 μm, it is preferred that the pore diameter of the porous PFA is smaller than that of toner. This configuration can inhibit toner from passing through the pressure-release filter **15**, thus suppressing toner scattering.

It is to be noted that, when the pore diameter of the porous PFA is 10 μm or smaller, the passage of carrier included in two-component developer can be prevented reliably.

Referring to FIG. **7**B, further a reinforcing member **16** is provided to the inner face of the pressure-release filter **15** facing the interior of the developing device **8** (i.e., the developer containing channels), at or adjacent to the periphery of the pressure-release filter **15**, to maintain the shape of the film-shaped pressure-release filter **15**. For example, the reinforcing member **16** has a thickness of about 0.3 mm and is constructed of PET (polyethylene terephthalate). The reinforcing member **16** may be bonded to the pressure-release filter **15**.

Reinforcing the pressure-release filter **15** with the reinforcing member **16** to maintain the shape of the pressure-release filter **15** to cover the pressure-release vent **5** is advantageous in facilitating removal of the pressure-release filter **15** from the development casing **80** and accordingly enhancing maintenance of the developing device **8** and replacement of the pressure-release filter **15**.

As shown in FIG. **7**C, the reinforcing member **16** is attached to the pressure-release filter **15** along the periphery of the pressure-release filter **15**, and it helps to maintain the shape of the pressure-release filter **15**. Although the reinforcement with the reinforcing member **16** means a reduction in the area of the pressure-release filter **15** through which air passes, the decrease can be alleviated by providing the reinforcing member **16** at or adjacent to the periphery of the pressure-release filter **15**.

Additionally, as shown in FIG. **7**B, the pressure-release filter **15** is attached, via the reinforcing member **16**, to an edge portion **80***a* of the development casing **80** enclosing the pressure-release vent **5**. Between the reinforcing member **16** and the edge portion **80***a*, a compressed sponge member **17**, serving as a compressed member, is provided to seal clearance therebetween. In the present embodiment, for example, the sponge member **17** is constructed of urethane and has a thickness of about 2.0 mm when not being compressed.

The pressure-release filter **15** and related components are disposed as follows. Place the sponge member **17** on the edge portion **80***a*. Then, dispose the pressure-release filter **15** to which the reinforcing member **16** is attached on the sponge member **17**. Further, attach a filter case **18** to the development casing **80** from outside the pressure-release vent **5** so that the filter case **18** presses down the reinforcing member **16** with the pressure-release filter **15** interposed therebetween. Then, the sponge member **17** is compressed to about 1.0 mm, being interposed between the reinforcing member **16** and the edge portion **80***a*. With the sponge member **17** compressed and interposed between the adjacent components in the portion where the pressure-release filter **15** is provided, sealing of the developing device **8** at the pressure-release vent **5** can be secured.

The image forming apparatus **500** further includes an exhaust duct, and air inside the apparatus is discharged by a negative pressure generator, such as an exhaust fan, through the exhaust duct to the outside. The filter case **18** shown in FIG. **7**B communicates with the exhaust duct, and the internal pressure of the developing device **8** is reduced by sucking air from the exhaust duct by the negative pressure generator.

In the present embodiment, since the reinforcing member **16** is attached (may be bonded) to the pressure-release filter **15** and the pressure-release filter **15** is made removable, clogging of the pressure-release filter **15** with developer can be eliminated by regular cleaning or replacement of the pressure-release filter **15**. The pressure loss at the pressure-release vent **5** can be inhibited by canceling the clogging of the pressure-release filter **15**, which can inhibit scattering of toner caused by the internal pressure rise of the developer container. Additionally, the maintenance of the developing device **8** can become easier.

Additionally, it is preferable that the pressure-release filter **15** be double-structured and a thin film of a typical filter material, such as raising materials, sponge, or the like, be attached to a porous fluoroplastic film.

FIG. **8** illustrating a variation of the pressure-release filter **15** according to the present embodiment. In the configuration shown in FIG. **8**, the pressure-release filter **15** be double-structured and includes a porous fluoroplastic layer **151** and a raising material layer **152**. Instead of the raising material layer **152**, sponge or the like may be provided on the porous fluoroplastic layer **151**.

When the pressure-release filter **15** is double-structured as shown in FIG. **8**, the pressure-release filter **15** is disposed with

the porous fluoroplastic layer **151** facing the inner side of the development casing **80** and the raising material layer **152** (or sponge, or the like) facing the outer side of the development casing **80**.

While the porous fluoroplastic film excels in surface smoothness and capability to release toner, its shape is unstable since it is film shaped. Accordingly, an inner area surrounded by the reinforcing member **16** is likely to deform, being pressed by the airflow passing through the pressure-release vent **5**. If the pressure-release filter **15** is repeatedly deformed by the airflow each time the developing device **8** is driven, there is a risk that the porous fluoroplastic film is damaged, thus degrading the capability of the pressure-release filter **15**.

By contrast, when the pressure-release filter **15** is double-structured as shown in FIG. **8** and the raising material layer **152** (or sponge, or the like) is provided on the outer side, the inner area of the porous fluoroplastic film can be pressed from the opposite side of the developer containing channels.

This configuration can inhibit deformation of the porous fluoroplastic film pressed by the airflow and accordingly reduce the resulting damage to the porous fluoroplastic film.

If the double-structured pressure-release filter **15** is disposed inside out such that the raising material layer **152** (or sponge, or the like) is opposed to the developer containing channels, clogging arises similarly to conventional filters. By contrast, when the reinforcing member **16** is provided to the porous fluoroplastic layer **151** of the pressure-release filter **15**, the reinforcing member **16** can be a mark to distinguish the porous fluoroplastic layer **151**. Accordingly, it can be a preventive to inhibit the raising material layer **152** (or sponge, or the like) from being disposed on the side of the developer containing channels erroneously.

It is to be noted that, although most of toner particles can be blocked when the pore diameter of the porous fluoroplastic film is smaller than the average particle size of toner, it is possible that a part of toner particles pass through the pores in the porous fluoroplastic film.

When the pressure-release filter **15** is double-structured, such toner particles passing through the porous fluoroplastic layer **151** can be captured by the raising material layer **152** (or sponge, or the like). Thus, leak of toner from the pressure-release vent **5** can be inhibited more reliably.

The various configurations according to the present inventions can attain specific effects as follows.

Aspect A: Aspect A concerns a developing device, such as the developing device **8**, that includes a developer bearer, such as the developing roller **11**, to carry developer on its surface and supply by rotation developer to a latent image on a latent image bearer, such as the photoreceptor **2**, in a development range facing the latent image bearer; a developer container, such as the development casing **80**, to contain developer; a pressure-release vent, such as the pressure-release vent **5**, in the developer container to discharge air from the developer container to outside the device, thereby inhibiting air pressure rises inside the developer container; and a filter, such as the pressure-release filter **15**, provided to the pressure-release vent to inhibit developer from being discharged from the pressure-release vent. In this developing device, the filter is constructed of a porous fluoroplastic film.

As described above, since the porous fluoroplastic film excels in surface smoothness and capability to release developer, developer is not likely to remain thereon even when the developer filtered adheres to the face of the filter on the inner side of the developer container. Accordingly, accumulation of developer on the filter and clogging of the filter caused thereby can be inhibited. Thus, aspect A can inhibit the clogging of the filter provided to the pressure-release vent.

Aspect B: In aspect A, the porous fluoroplastic includes porous PFA.

As described above, this configuration enables the filter to inhibit clogging thereof resulting from the accumulation of developer thereon.

Aspect C: In aspect A or B, the filter, such as the pressure-release filter **15**, is provided with a reinforcing member such as the reinforcing member **16** so that the filter maintains the shape to cover the pressure-release vent.

According to aspect C, as described above, the porous fluoroplastic film that is film-shaped and is not handled easily can be reinforced to maintain its shape, thus facilitating the handling thereof. Accordingly, removal of the filter can be easier, and maintenance and replacement can be facilitated.

Aspect D: In aspect C, the reinforcing member is attached to the filter along the periphery of the filter.

As described above, this configuration contributes to maintaining the shape of the filter and simultaneously alleviates the reduction in the area of the filter through which air passes.

Aspect E: In aspect C or D, the filter is provided to the developer container, such as the development casing **80**, via the reinforcing member, and the clearance between the reinforcing member and the developer container is sealed with a compressed member, such as the sponge member **17**.

With this configuration, as described above, sealing of the portion where the filter is provided can be secured, and simultaneously, removal of the filter can be easy.

Aspect F: A process cartridge, such as the image forming unit **1**, removably installed in an image forming apparatus includes the developing device according to any of aspects A through E and at least one of the latent image bearer, such as the photoreceptor **2**, a charging member, such as the charging device **6**, to charge the latent image bearer, and a cleaning device, such as the cleaning device **3**, to clean the latent image bearer.

As described above, aspect F can attain, as the developing device incorporated in the process cartridge, a developing device capable of inhibiting clogging of the filter provided to the pressure-release vent.

Aspect G: In an image forming apparatus that includes the latent image bearer, such as the photoreceptor **2**; a latent image forming unit, such as the exposure device **40**, to form a latent image on the latent image bearer; a transfer member, such as the primary-transfer roller **35**, the intermediate transfer belt **31**, and the secondary-transfer roller **36**, to transfer a toner image from the latent image bearer onto a sheet of recording media; the developing device according to any of aspects A through E is used.

According to aspect G, as described above, since the clogging of the filter provided to the pressure-release vent can be inhibited, reliable image formation can be secured with toner scattering resulting from the clogging suppressed.

Aspect H: In an image forming apparatus including the latent image bearer, such as the photoreceptor **2**, the charging member such as the charging device **6** to charge the latent image bearer, the developing device to develop the latent image on the latent image bearer into a toner image, the cleaning device such as the cleaning device **3** to clean the latent image bearer, the transfer member, such as the primary-transfer roller **35**, the intermediate transfer belt **31**, and the secondary-transfer roller **36**, to transfer the toner image from the latent image bearer onto a sheet of recording media; multiple process cartridges according to aspect F are used.

According to aspect H, since the image forming apparatus includes the multiple process cartridges incorporating the

developing device capable of inhibiting toner scattering resulting from the clogging of the filter, color image formation can be reliable.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A developing device comprising:

a developer bearer to carry by rotation developer to a development range facing a latent image bearer;

a developer container to contain developer and having a pressure-release vent to discharge air from the developer container to outside the developing device;

a filter provided to the pressure-release vent to inhibit developer from being discharged through the pressure-release vent, the filter including a porous fluoroplastic film; and

a reinforcing member to reinforce the filter to maintain a shape of the filter to cover the pressure-release vent,

wherein the filter is provided to the developer container via the reinforcing member,

wherein a compressed member is provided between the reinforcing member and the developer container to seal clearance therebetween,

wherein the compressed member is a sponge, and

wherein the reinforcing member is thin and planar.

2. The developing device according to claim **1**, wherein the porous fluoroplastic film comprises a porous PFA film.

3. The developing device according to claim **1**, wherein the reinforcing member is bonded to the filter along a periphery of the filter.

4. A process cartridge removably installed in an image forming apparatus, the process cartridge comprising:

the developing device according to claim **1**; and

at least one of the latent image bearer, a charging member to charge the latent image bearer, and a cleaning device to clean the latent image bearer.

5. An image forming apparatus comprising:

the latent image bearer;

a latent image forming unit to form a latent image on the latent image bearer;

the developing device according to claim **1**, to develop the latent image into a toner image; and

a transfer member to transfer the toner image onto a recording medium.

6. An image forming apparatus comprising multiple process cartridge removably installed in the image forming apparatus,

the multiple process cartridges each including the developing device according to claim **1** and at least one of the latent image bearer, a charging member to charge the latent image bearer, and a cleaning device to clean the latent image bearer.

7. A developing device comprising:

a developer bearer to carry by rotation developer to a development range facing a latent image bearer;

a developer container to contain developer and having a pressure-release vent to discharge air from the developer container to outside the developing device; and

a filter provided to the pressure-release vent to inhibit developer from being discharged through the pressure-release vent, the filter including a porous fluoroplastic film,

wherein the filter further comprises a raising material attached to the porous fluoroplastic film.

8. A developing device comprising:

a developer bearer to carry by rotation developer to a development range facing a latent image bearer;

a developer container to contain developer and having a pressure-release vent to discharge air from the developer container to outside the developing device; and

a filter provided to the pressure-release vent to inhibit developer from being discharged through the pressure-release vent, the filter including a porous fluoroplastic film,

wherein the filter further comprises a raising material attached to the porous fluoroplastic film, and

wherein the raising material is disposed facing an outer side of the developer container.

* * * * *